

CLAIMS

1. A control system for use with a machine having a tool arranged to move through a known path of movement, the control system characterised by comprising:

5 a means for detecting the location of objects in or adjacent the path of the tool; and a processing and control means arranged to determine the distance between the objects in or adjacent the path of the tool and a leading edge of the tool;

wherein the control system includes a first mode of operation in which the processing and control means controls movement of the tool such that the distance between the objects in or adjacent the path of the tool and the leading edge of the tool is

10 maintained within minimum and maximum values.

2. A control system in accordance with claim 1 characterised in that the means

for detecting the location of objects in or adjacent the path of the tool comprises a

light emitting means arranged to illuminate a region around the path and a light

receiving means arranged to receive light that has passed through the region such that

15 objects in the region cast shadows on the light receiving means, wherein the light

receiving means is in communication with the processing and control means such that

the processing and control means recognises the presence of obstructions in the region

by the images received by the light receiving means.

3. A control system in accordance with claim 2 characterised in that the

20 processing and control means includes a memory means, the memory means being

arranged to store images received by the light receiving means as known images.

4. A control system in accordance with claim 3 characterised in that the

processing and control means includes a means to receive known images from an

external source.

5. A control system in accordance with claim 3 or 4 characterised in that the known images are assigned to portions of the memory means corresponding to a particular known machine operation.

6. A control system in accordance with any one of claims 3 to 5, wherein the
5 machine is a press brake having an anvil and the tool is arranged to strike material placed on the anvil to bend the material.

7. A control system in accordance with claim 6 characterised in that the maximum value is selected such that the tool and the anvil remain in the field of view of the light receiving means and the minimum value is chosen to be a large enough
10 value such that material can be easily placed onto or removed from the anvil.

8. A control system in accordance with claim 6 or 7, characterised in that the maximum and minimum values are varied dependent on how closely the image received by the light receiving means matches a known image stored in the memory means.

15 9. A control system in accordance with any one of claims 6 to 8 characterised in that the control system remains in the first mode of operation while the image received by the processing and control means does not match one of the known images.

20 10. A control system in accordance with claim 9, characterised in that an approach switch is provided and the control system only remains in the first mode of operation while the approach switch is activated by an operator.

25 11. A control system in accordance with any one of claims 6 to 10 characterised in that a second mode of operation is provided, wherein when the control system is in the second mode of operation, the tool is moved toward the material to a distance closer than said minimum distance.

12. A control system in accordance with claim 11, characterised in that, in the second mode of operation, the tool is moved to a distance from the material such that an operator cannot insert fingers between the tool and the material.

5 13. A control system in accordance with claim 11 or 12, characterised in that the control system moves from the first mode of operation to the second mode of operation when the processing and control means recognised that a portion of the image received by the light receiving means, said portion being the shape and orientation of the material on the anvil, match with a corresponding portion of one of the known images.

10 14. A control system in accordance with claim 11 or 12 characterised in that the control system moves from the first mode of operation to the second mode of operation when the processing and control means recognises the image received by the light receiving means as being one of said known images.

15 15. A control system in accordance with claim 10, characterised in that the control system only remains in the second mode of operation while the approach switch is activated by an operator.

20 16. A control system in accordance with claim 9, characterised in that the control system moves from the first mode of operation to the second mode of operation on release and reassertion of the approach switch by the operator and images received by the processing and control means are used to create a known image while the tool moves toward the anvil in the second mode of operation.

17. A control system in accordance with any one claims 6 to 12, characterised in that a third mode of operation is provided, wherein when the control system is in the third mode of operation, the tool is moved to bend the material on the anvil.

18. A control system in accordance with claim 17, characterised in that the known image created in the second mode of operation is saved to the memory means as a known image after the bend is commenced.

5 19. A control system in accordance with claim 17 or 18 characterised in that the control system moves from the second mode of operation to the third mode of operation upon release and reassertion of the approach switch.

10 20. A control system in accordance with any one of claims 6 to 19, characterised in that a fourth mode of operation is provided, wherein when the control system is in the fourth mode of operation, the tool is unconditionally retracted away from the anvil.

21. A control system in accordance with claim 20 characterised in that the control system is provided with a retract switch and the control system moves to the fourth mode of operation when an operator activates the retract switch.

15 22. A control system in accordance with any one of claims 3 to 21, characterised in that when the control system is in the first mode of operation, the processing and control means defines within the images received by the light receiving means: a retract zone, being around the tool, such that if the nearest objects to the tool are detected in the retract zone, the tool is moved away from the objects; a stop zone, being around the retract zone, such that if the nearest objects to the tool are detected in the stop zone, the tool movement is stopped; and a first approach zone, being around the stop zone, such that if the nearest objects to the tool are detected in the first approach zone, the tool is moved toward the objects.

20

25 23. A control system in accordance with claim 22, characterised in that the processing and control means defines a second approach zone, being around the first approach zone, such that if the nearest objects to the tool are detected in the second

approach zone, the tool is moved toward the objects at a speed relatively faster than movement of the tool occurring when the nearest objects to the tool are in the first approach zone.

24. A control system in accordance with any one of claims 3 to 23, characterised in that the tool speed is varied based on the distance between the tool and the boundary of the area defined between said minimum and maximum values to provide smooth movement of the tool.

5 25. A control system in accordance with any one of claims 2 to 24 characterised in that the light emitting means includes a laser diode and the current through the laser boundary of the area defined between said minimum and maximum values to provide smooth movement of the tool.

10 10 diode is modulated to create varying speckle patterns and thereby improve resolution of the received image.

15 15 26. A control system in accordance with claim 25, characterised in that the light receiving means includes a screen on which the light passing through the region is incident, the screen being textured to further reduce the effect of speckle patterns produced by the laser diode.

20 20 27. A control system in accordance with any one of claims 2 to 26, characterised in that the light emitting means includes an adjustment means comprising a plurality of linear actuators, the linear actuators being connected to the light emitting means and arranged to move in a direction parallel to the axis of the emitted light such that linear movement of any one of the linear actuators changes the direction of the emitted light and movement of all of the linear actuators moves the light emitting means optically closer to or further from the light receiving means.

25 25 28. A control system in accordance with any one of the preceding claims, characterised in that the processing and control means comprises a software program residing on a digital signal processor.